Movement

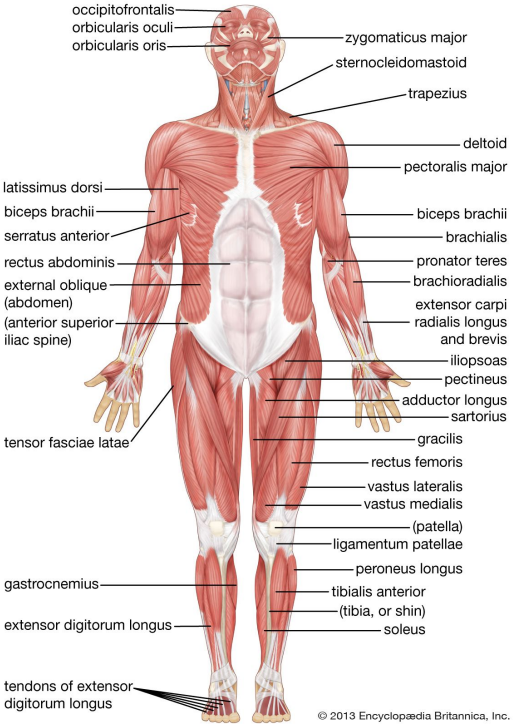
Topic 11.2

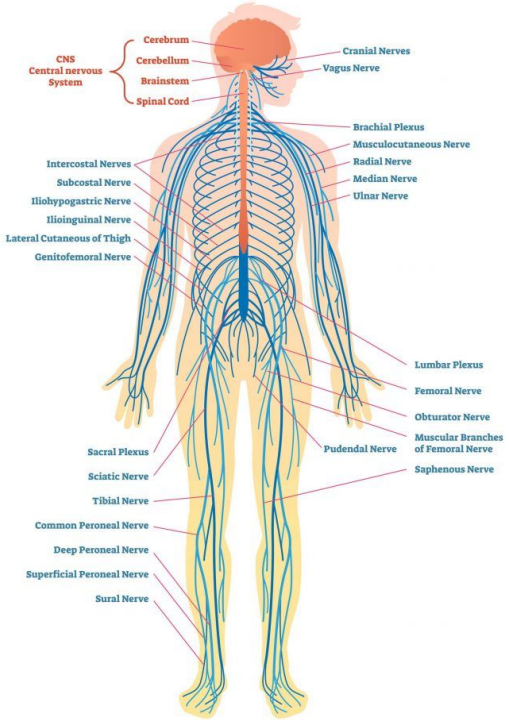
Understandings

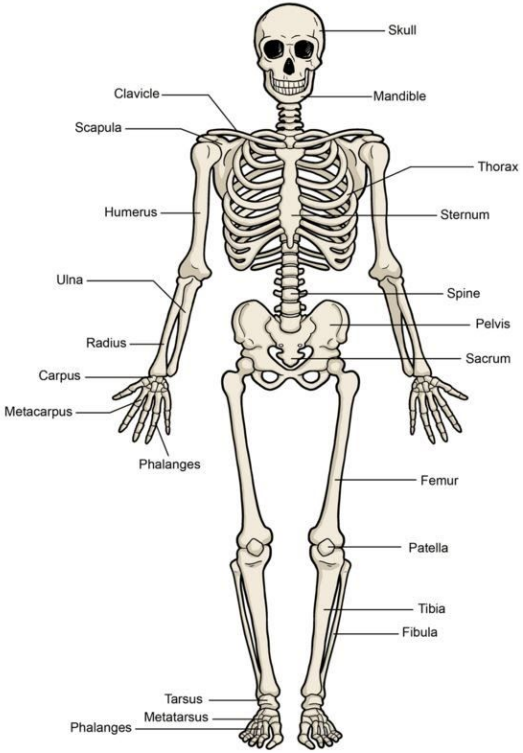
- Bones and exoskeletons provide anchorage for muscles and act as levers
- Synovial joints allow certain movements but not others
- Movement of the body requires muscles to work in antagonistic pairs
- Skeletal muscle fibres are multinucleate and contain specialised endoplasmic reticulum
- Muscle fibres contain many myofibrils
- Each myofibril is made up of contractile sarcomeres
- The contraction of the skeletal muscle is achieved by the sliding of actin and myosin filaments
- ATP hydrolysis and cross bridge formation are necessary for the filaments to slide
- Calcium ions and the proteins tropomyosin and troponin control muscle contractions

Movement in the human body

Movement is dependent on 3 organ systems in the body:







Skeletal System

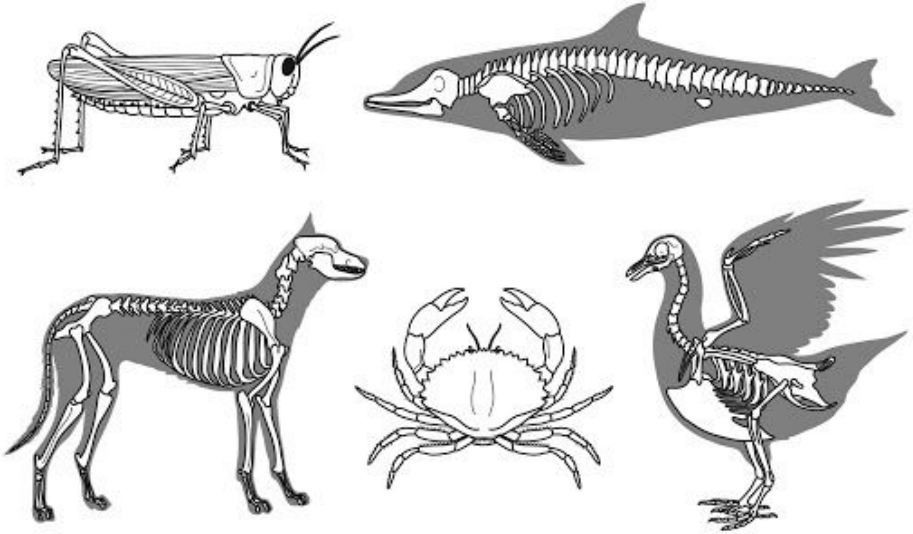
Not all organisms have a skeleton.

The functions of a skeleton: support and attachment points for muscles

Those that do, either have an exoskeleton or an endoskeleton.

1. Exoskeleton: Skeleton is outside their body
   - Insects, Crustaceans, etc.
   - Made of chitin - a polysaccharide

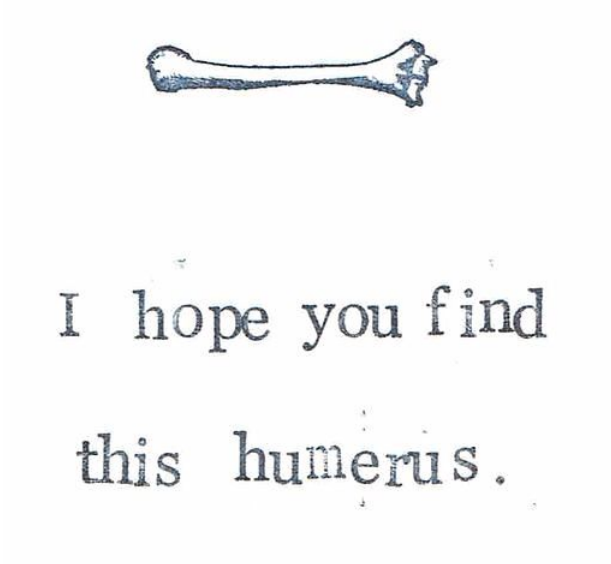
2. Endoskeleton: Skeleton is inside their body.
   - Vertebrates
   - Made of bone- calcified material

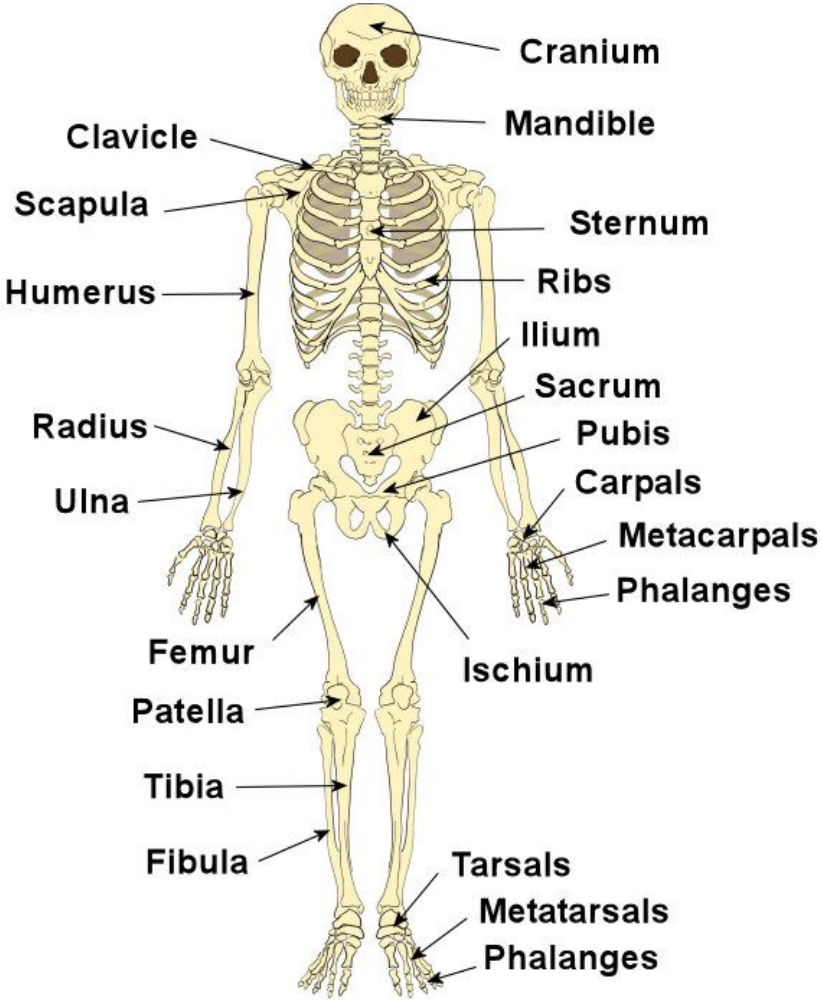


Human Skeletal System

Ligament: helps bones connect to bones

Tendons: helps bones connect to muscles





Bone to Muscle attachment

When bones attach to muscles, they create levers.

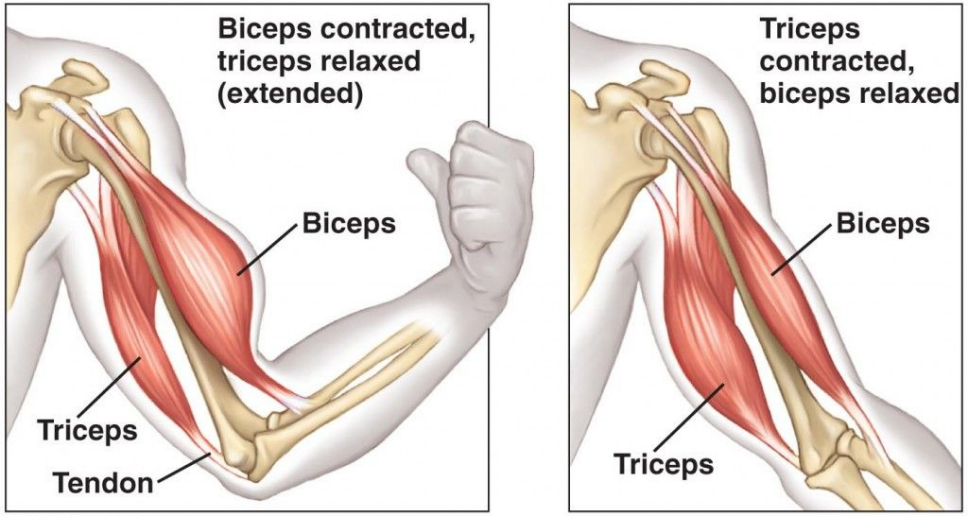
Organisms with exoskeletons are such that when their muscles attach to bone, it gives them WAY more leverage..

- Carry objects many times larger their size
- Jump over distances many times longer than their own length

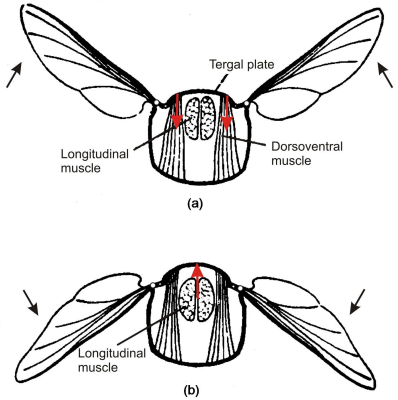
Antagonistic Pairs

Antagonistic Pairs: Two muscles that attach to the same bones but are responsible for opposite movements. When one contracts, the other relaxes, and vice versa. Levers and Anchors.

- Quadriceps and hamstrings
- Biceps and Triceps
- Diaphragm and interior intercostal muscles



Autonomous Insect Flight



Antagonistic Pairs

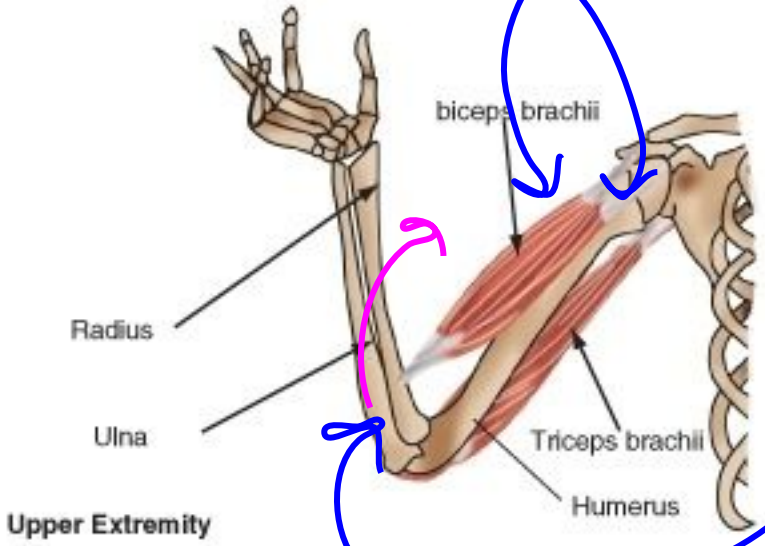
Anchor site/ORIGIN: Doesn't move

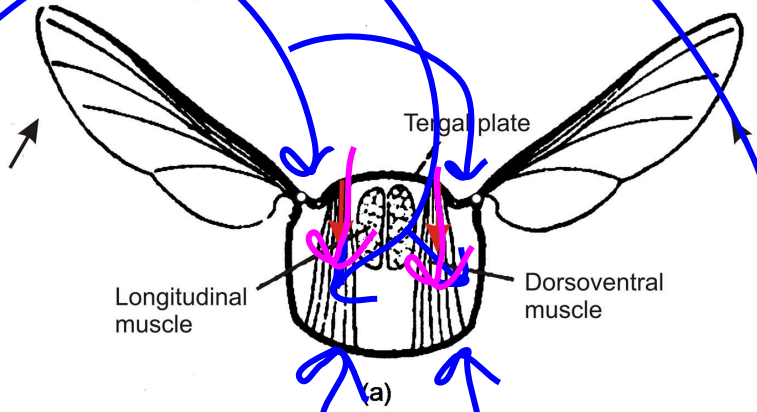
Lever/INSERTION: Moves the muscle/shortens the muscle

Attachment/Anchor Site

Muscle

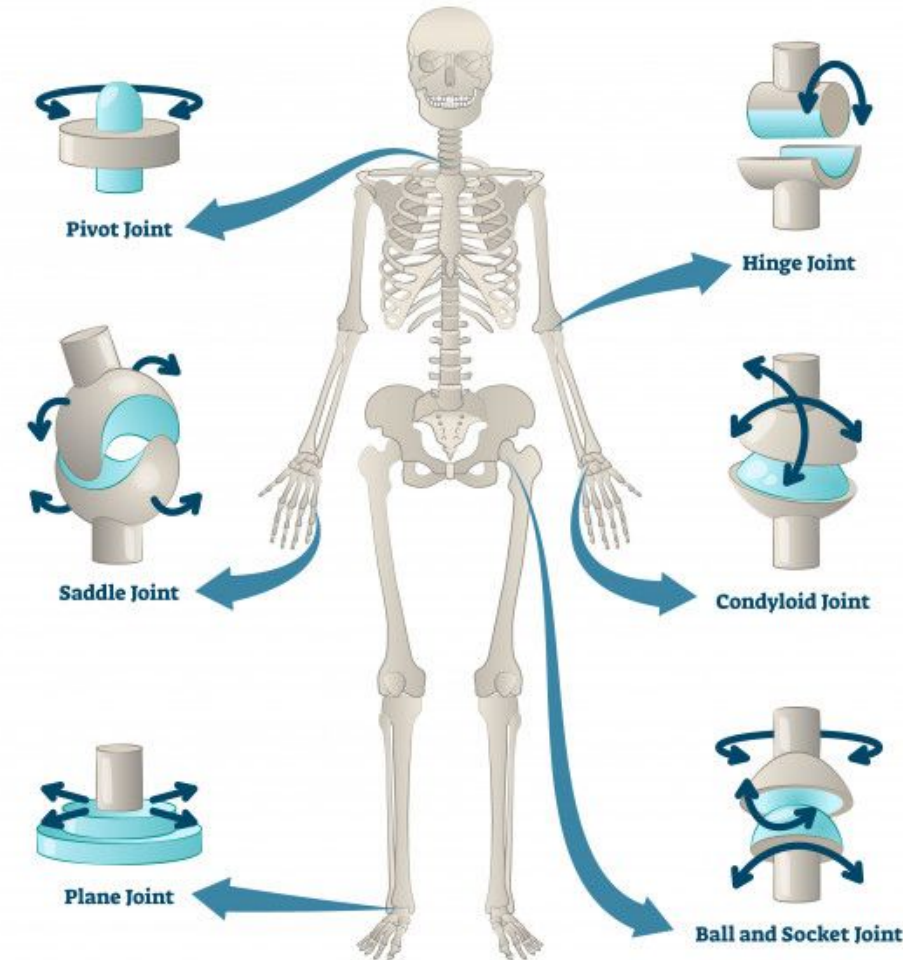
Lever





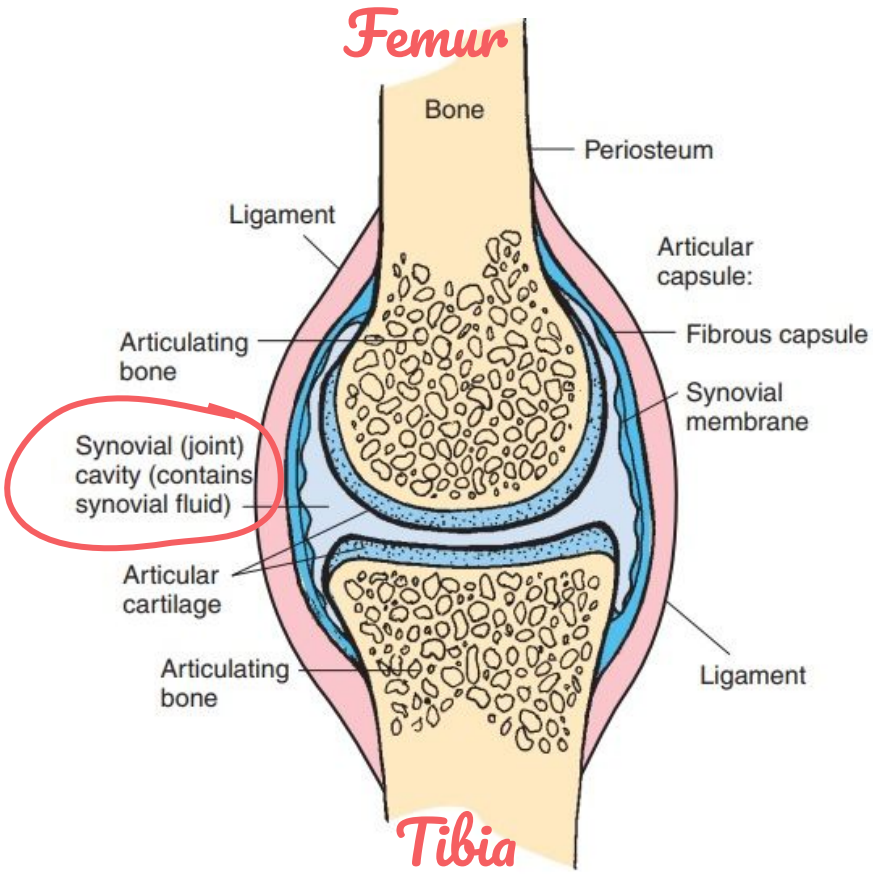
Joints

- Allows movement.
- Areas where two or more bones come together.
- 6 types of joints in our body
  - Ball and socket: hip and femur (hip) (most mobility)
  - Saddle: metacarpal and carpal (fingers)
  - Condyloid joint: metacarpal and phalange (wrist)
  - Pivot joint: between the vertebrae (backbone)
  - Hinge joint: humerus and ulna (elbow)
  - Plane joint: tarsals (ankle) (least mobility)
- Synovial fluid: provides oxygen and nutrients to the cartilage and also serve as lubrication between the bones
- Joint capsule: holds the synovial fluid in place
- Cartilage: lines the bone and absorbs shock

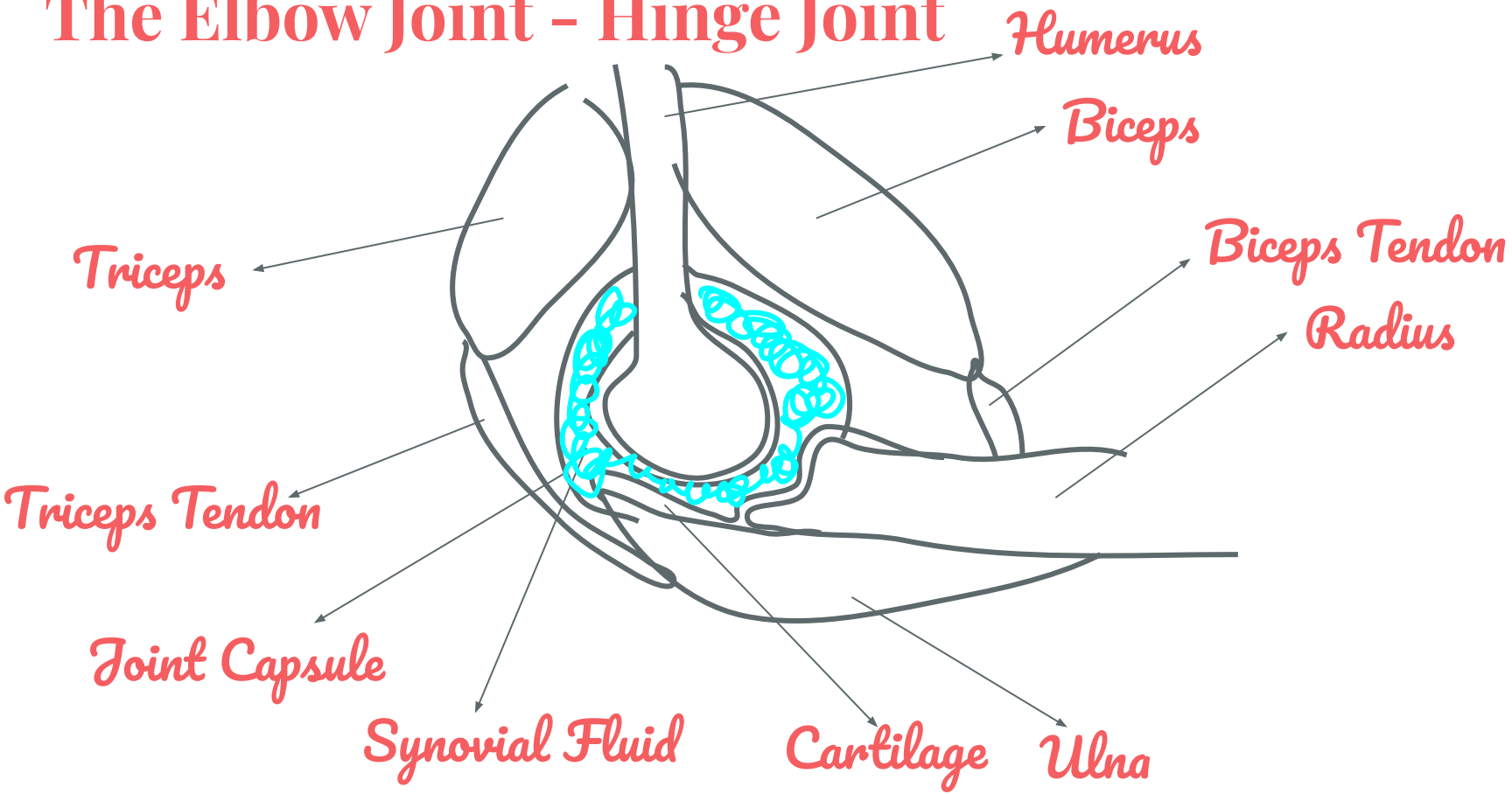


Synovial joints

- Synovial Joint: area where two bones meet. Area is surrounded by a fluid filled capsule. Fluid is called synovial fluid. Ex.: Knee
- Synovial joints have restricted movement (elbow vs. shoulder for example)
- Synovial fluid limits the range of motion of the joints



The Elbow Joint - Hinge Joint



Elbow Joint Structures and Function

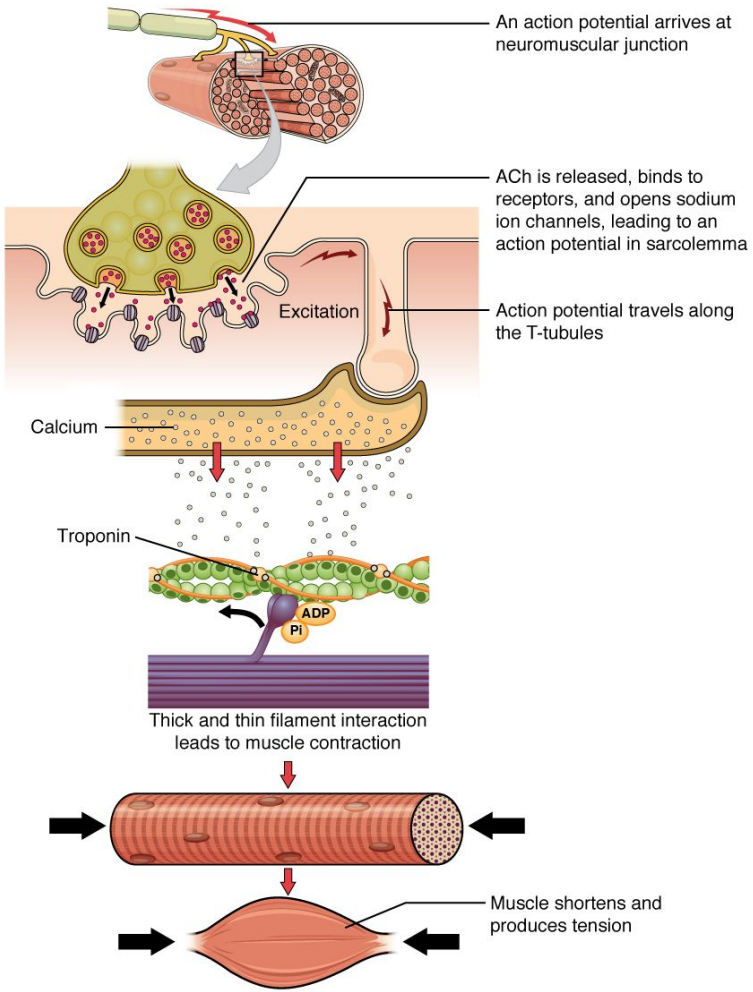
Structure	Function
Bones	
Humerus	Anchors muscle (muscle origin)
Radius	Acts as forearm lever for biceps
Ulna	Acts as forearm lever for triceps
Muscles	
Biceps	Bends the forearm (flexion)
Triceps	Straightens the forearm (extension)
Joint	
Joint capsule	Seals joint space and limits range of movement to promote stability
Synovial fluid	Provides food, oxygen and lubrication to the cartilage
Cartilage	Allows smooth movement (reduces friction), absorbs shock and distributes load

Homework

- Antibody Production Review
- Memorize Bones in the human body

Agenda

How the muscle contracts!



Muscle Cell Features

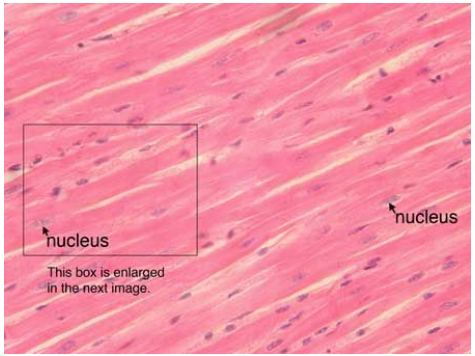
Sarcoplasm, Sarcoplasmic Reticulum, Sarcolemma.

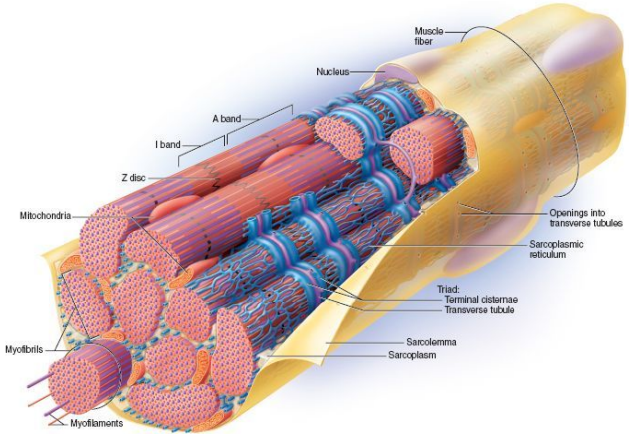
Lots of mitochondria in order to perform cellular respiration at high rates to generate ATP

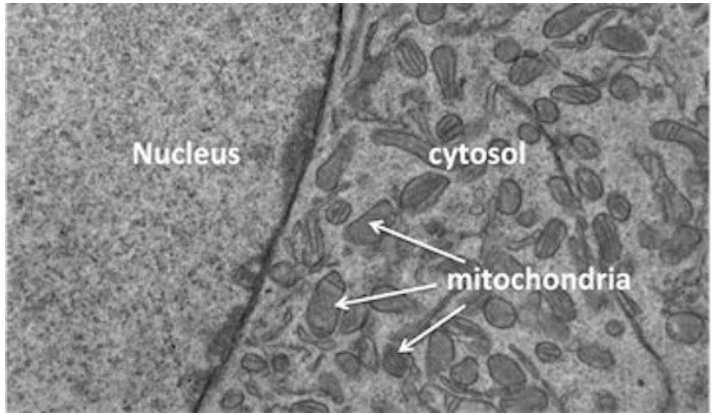
Stores lots of glycogen (a polysaccharide made of many glucose molecules). Glucose is needed for cellular respiration

ATP is needed for contractions → movement

Has may nuclei (because when they are created, it's through the fusion of many cells to allow them to perform more contractions and get this long shape)



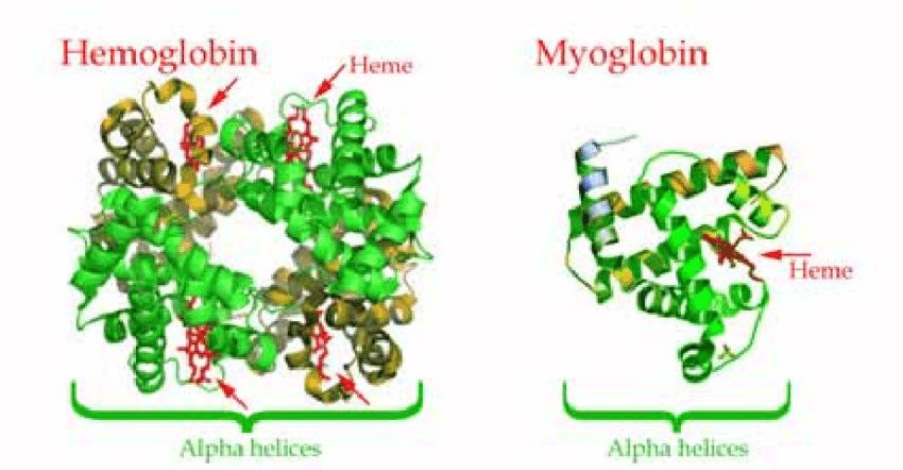




Myoglobin

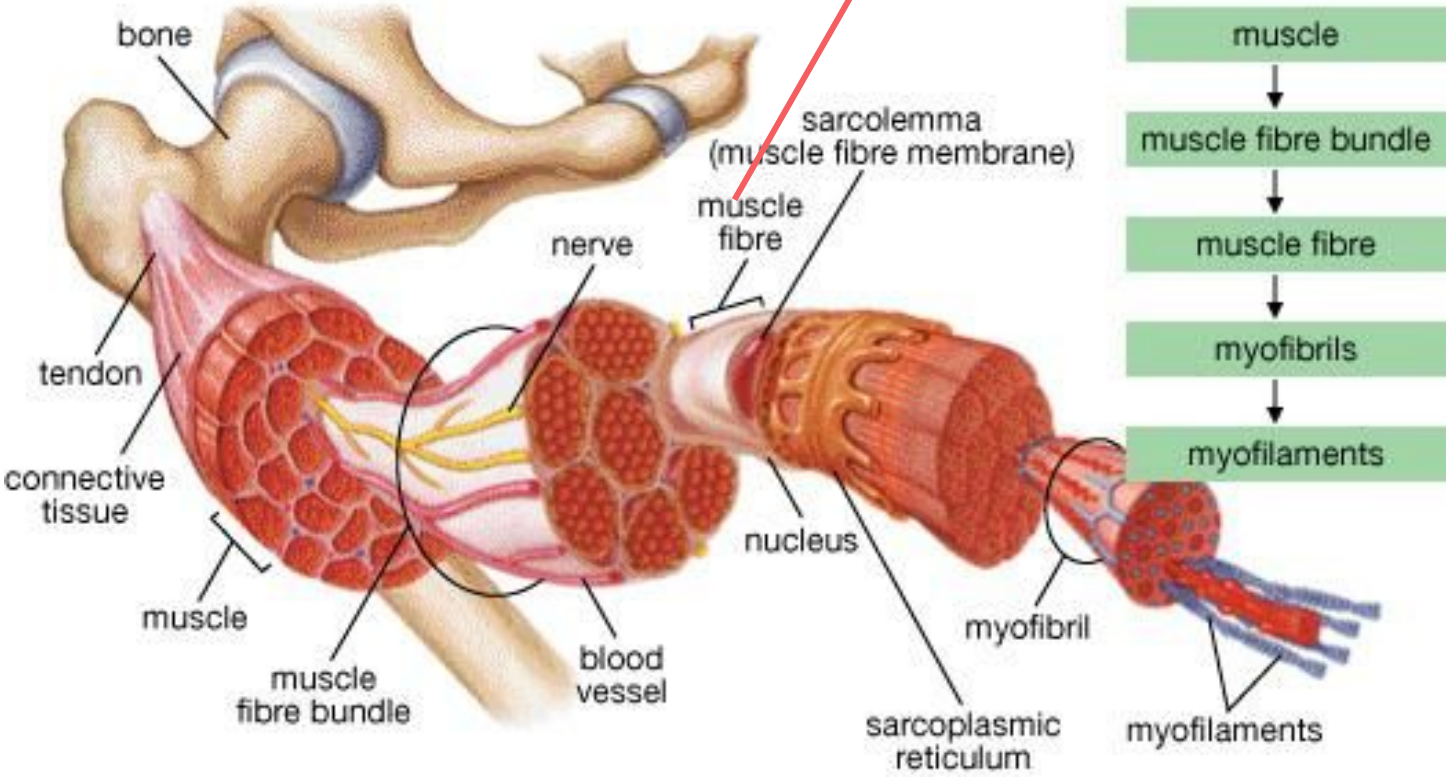
Hemoglobin: is attached to 4 oxygen molecules and provides oxygen to our blood and other cells.

Myoglobin: specific to muscles. Carries one oxygen molecule. Is kept for using as a last resort if out body runs out of oxygen. Has a high affinity for oxygen so it really holds onto it until our body is in need.



Muscle Cell Anatomy

Muscle fiber = Muscle cell



Myofibril

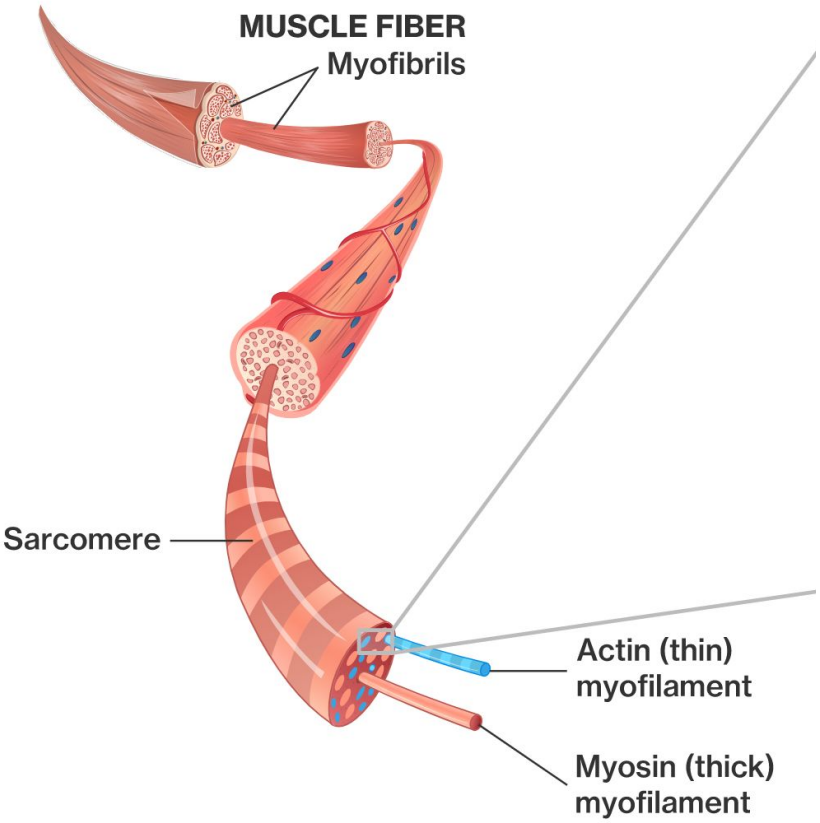
Myofibrils are the ‘tubes’ that make up the muscle cell

Myofibrils are made up of sarcomeres

Sarcomeres are made of of tiny bundles of actin and myosin

- Actin: thin myofilament
- Myosin: thick myofilament

Actin and myosin move and that is what causes our muscles to contract

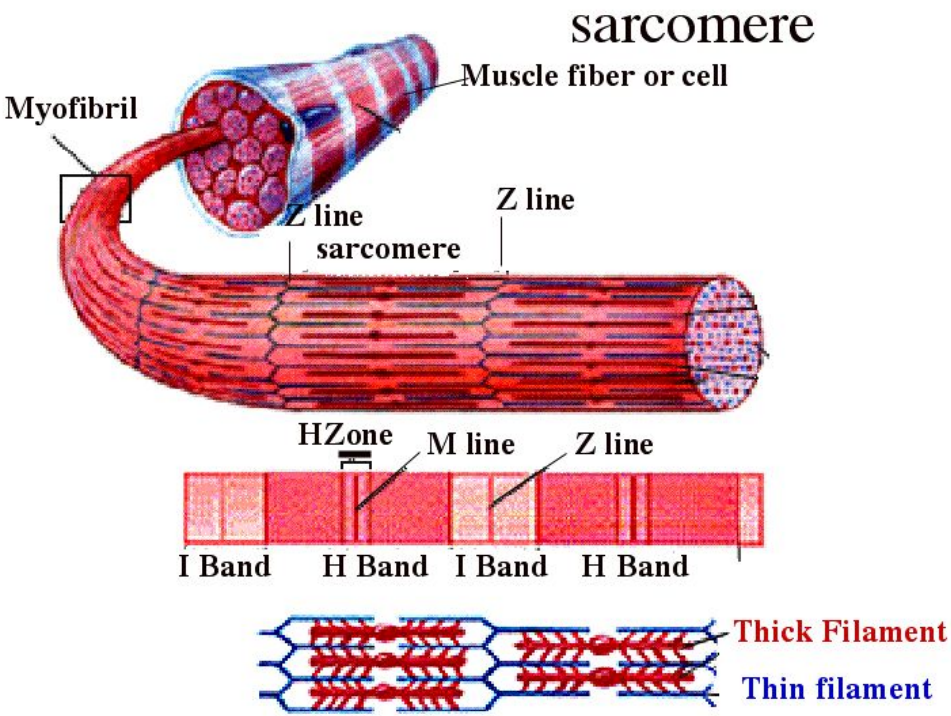


Myofibril ↠ Sarcomeres

Repeating units of actin and myosin are called sarcomeres

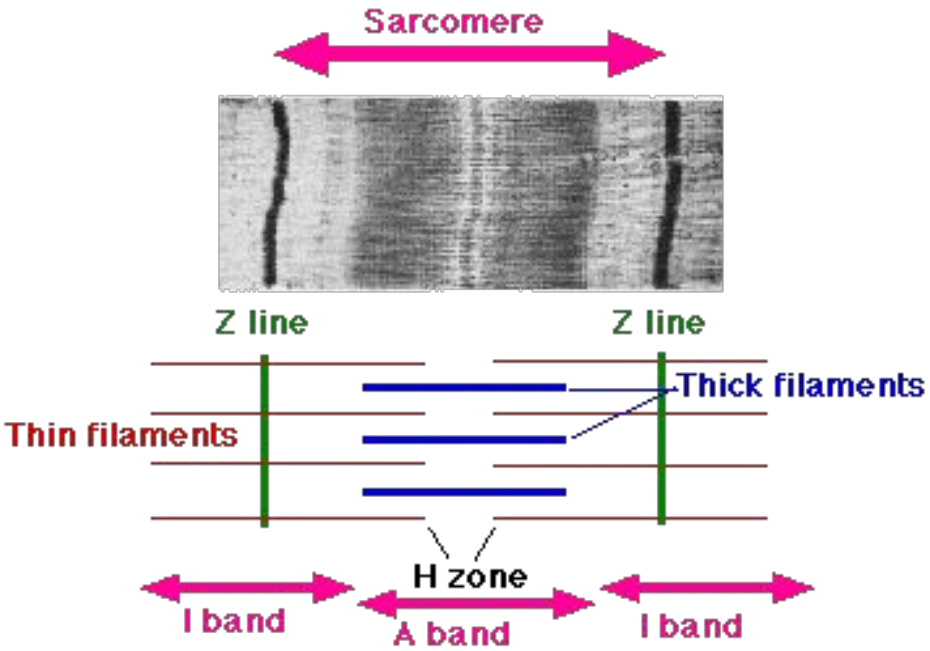
In our myofibril:

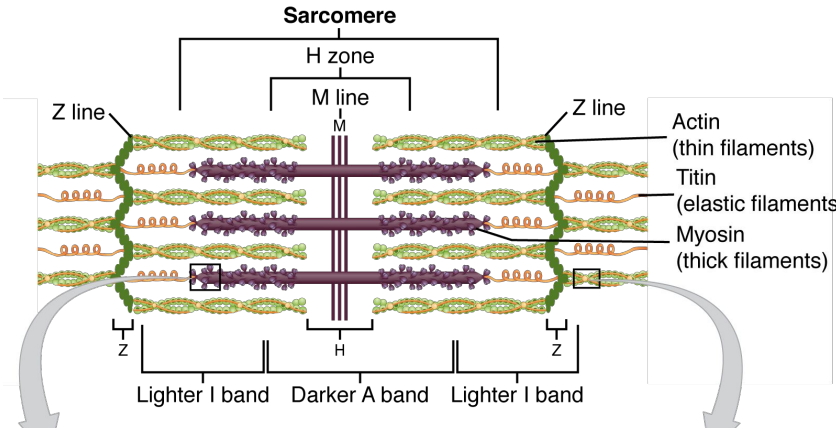
- Blue is actin
- Read is myosin



Sarcomere

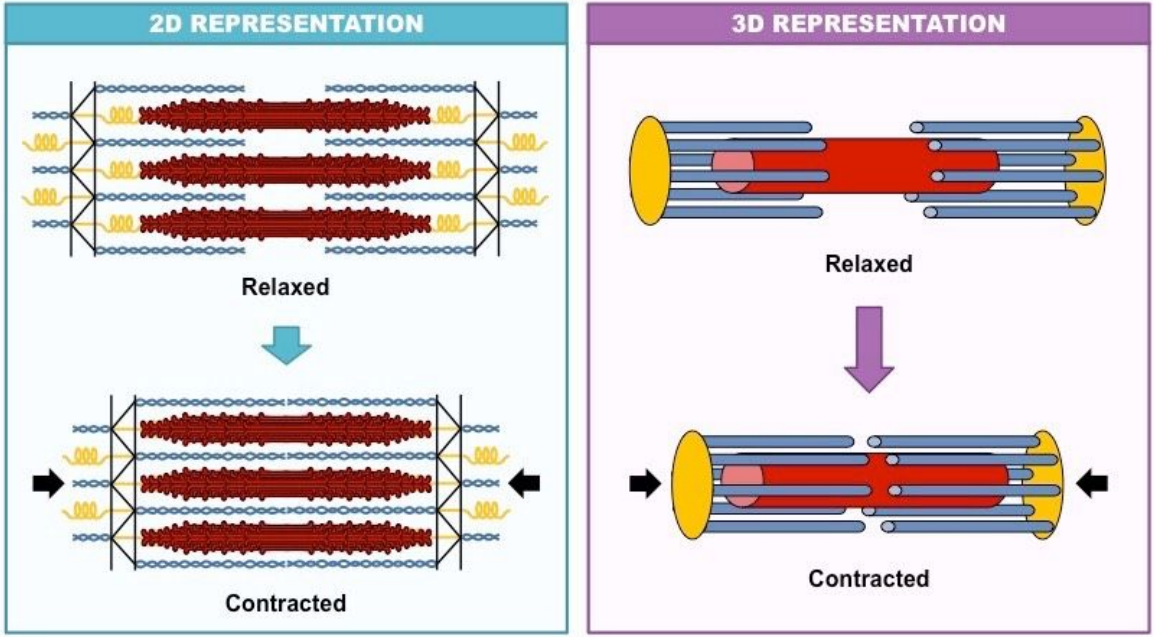
- The area between Z lines is one sarcomere





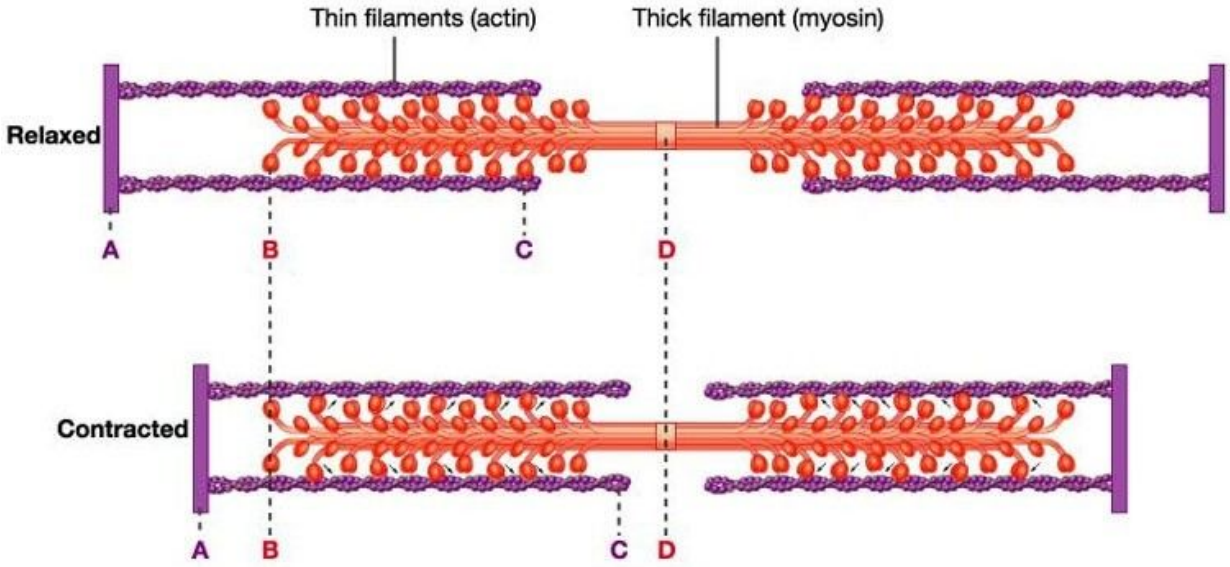
Muscle contraction

- When our muscles contract, myosin stays still, and actin filaments slide in towards each other
- Z lines will come closer together and shorten the sarcomere
- Our muscle shorten when it contracts



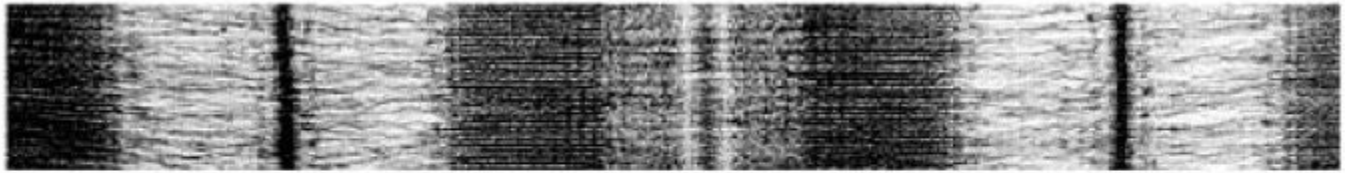
Myosin and Actin Shortening our Muscle

- Myosin is going to grab onto actin and pull it in
- Actin will slide inwards, bringing together the Z lines, shortening the sarcomere, and shortening the muscle



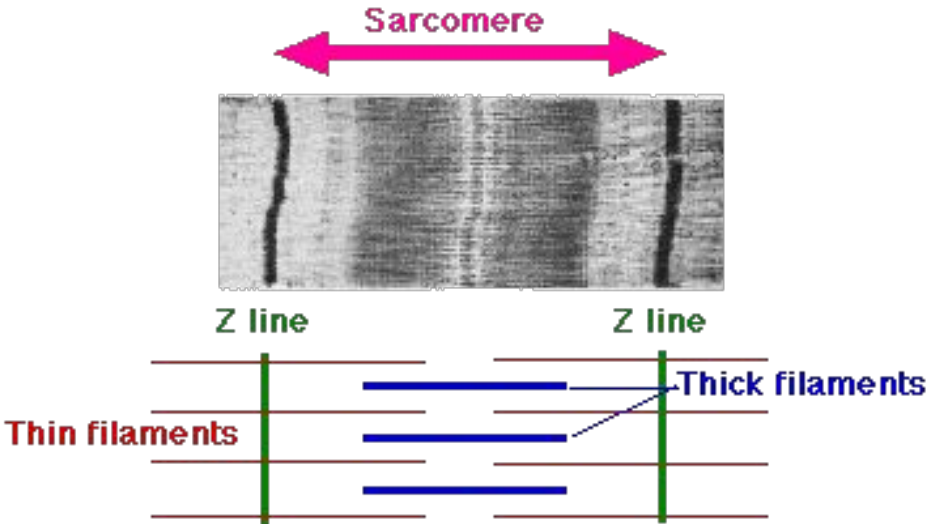
Contracted or Relaxed?

Relaxed



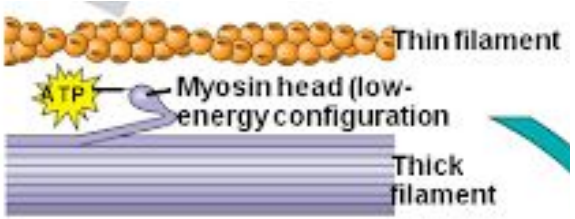
Contracted

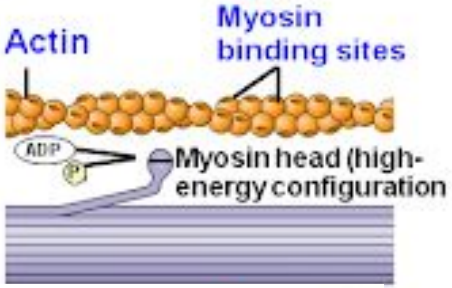
Draw a relaxed and contracted sarcomere

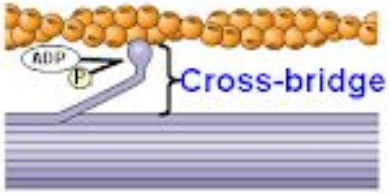


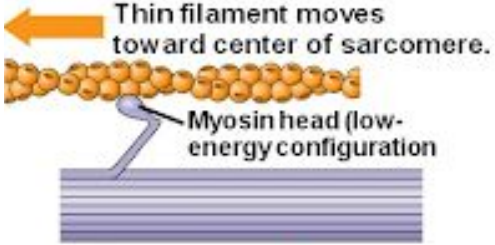
Sliding Filament Theory

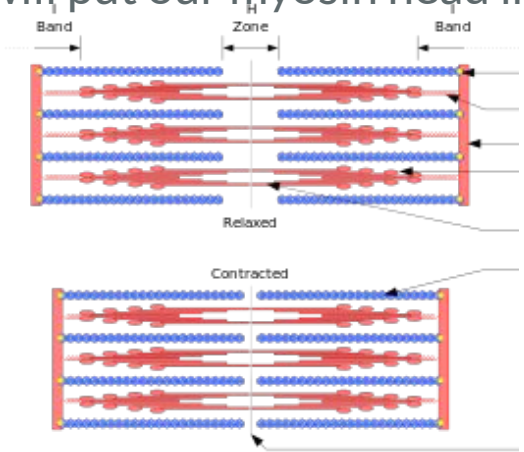
1. ATP hydrolyzes (splits) to activate myosin heads
2. Myosin head releases ADP and Pi, making is stand upright
3. Myosin head attaches to actin, creating a crossbridge
4. Because myosin head gets pushed inwards, it allows the actin to slide toward the middle
5. ATP will reattach and this will put our myosin head in a low-energy confirmation



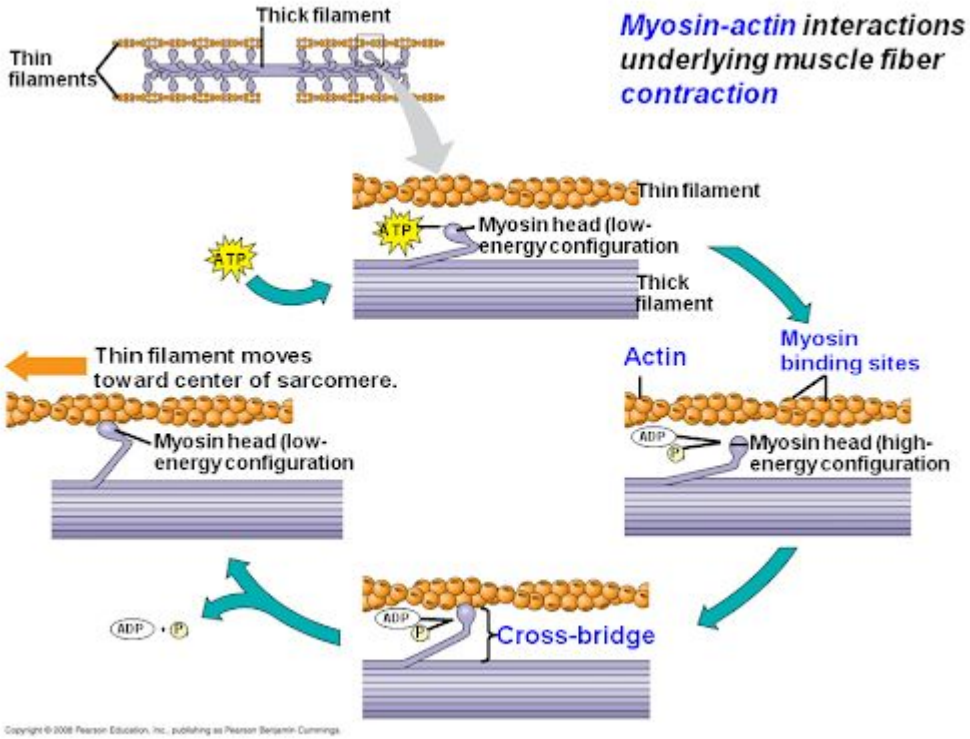






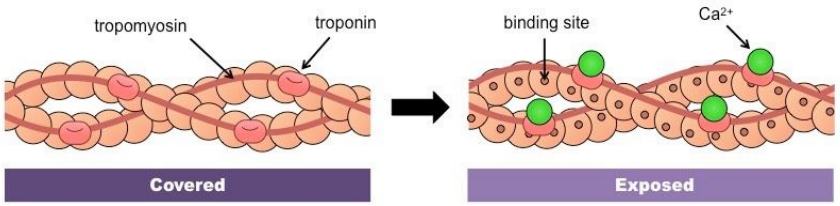


Sliding Filament Theory - Summary



Tropomyosin and Troponin

- Actin: When we zoom into actin, it looks like beads. The holes on each of these beads is a binding site for myosin (a protein)
- Tropomyosin: The ‘string’ that can cover the binding sites on actin (a protein)
- Troponin: Attached to the tropomyosin at different points (a protein)
    - Troponin attached to calcium
    - This causes it to pull the tropomyosin to the side, exposing myosin binding sites



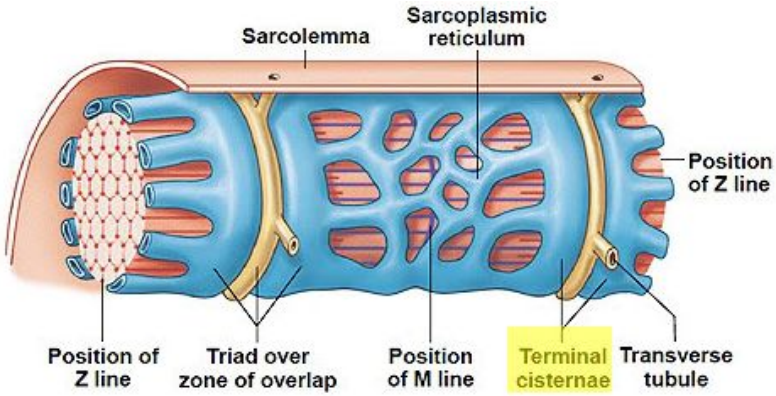
When calcium binds to troponin, it moves tropomyosin to the side, making myosin binding sites available

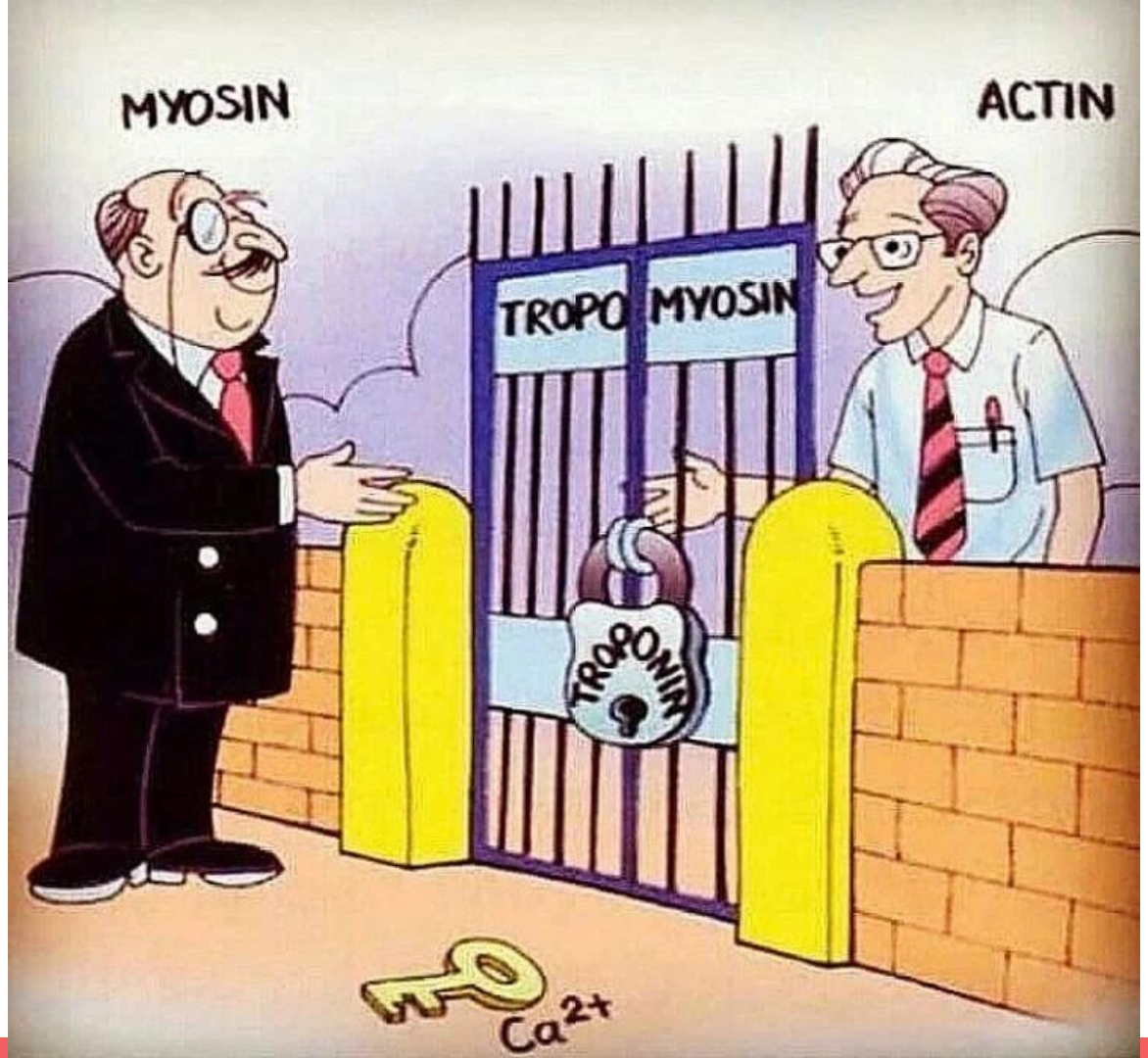
Sarcoplasmic Reticulum

Regulates the calcium ion concentration

If we want a contraction, sarcoplasmic reticulum will make sure there is a HIGH concentration of calcium ions

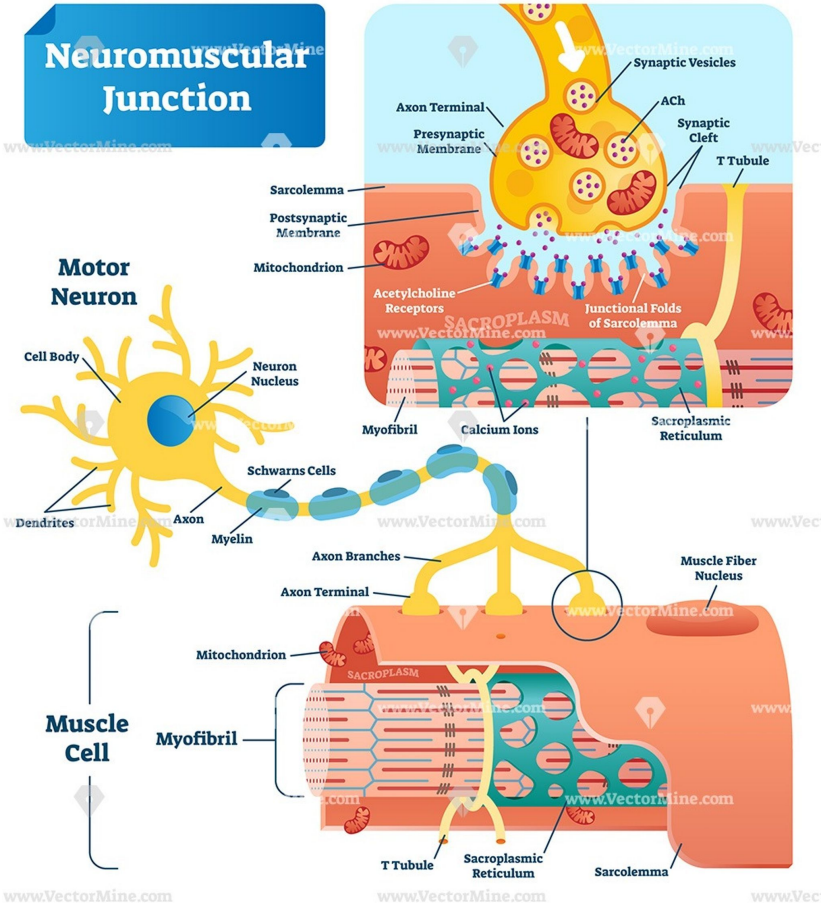
If we don't want a contraction, sarcoplasmic reticulum will make sure there is a LOW concentration of calcium ions



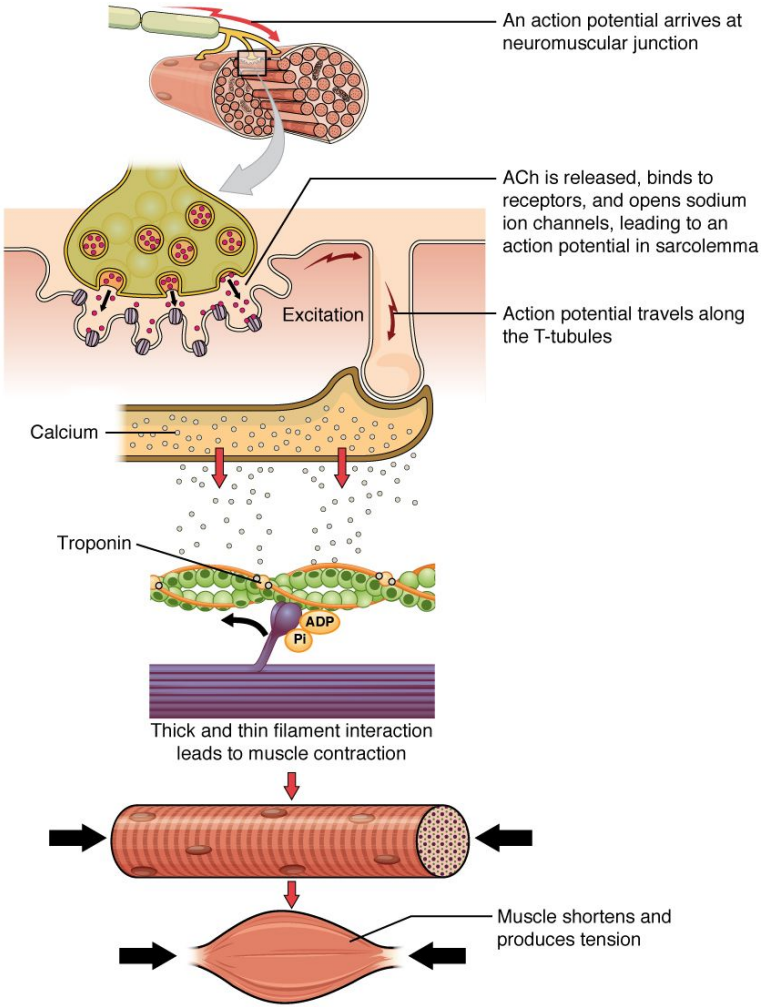

MYOSIN
ACTIN
TROPO MYOSIN
TROPONIN
Ca^{2+}

Neuromuscular junction

- Before a muscle contracts, it has to receive a signal from a motor neuron
- Motor neuron carries that action potential to the neuromuscular junction (area between neuron and muscle)
- When action potential reaches the end of the motor neuron it releases acetylcholine neurotransmitters in the synaptic cleft
- Acetylcholine binds to receptors on sarcolemma (muscle cell membrane)
- This causes depolarization (sodium ion rush into the cell). Depolarization is spread across the cell via T-tubules
- Rush of sodium ion in causes sarcoplasmic reticulum to secrete calcium ions



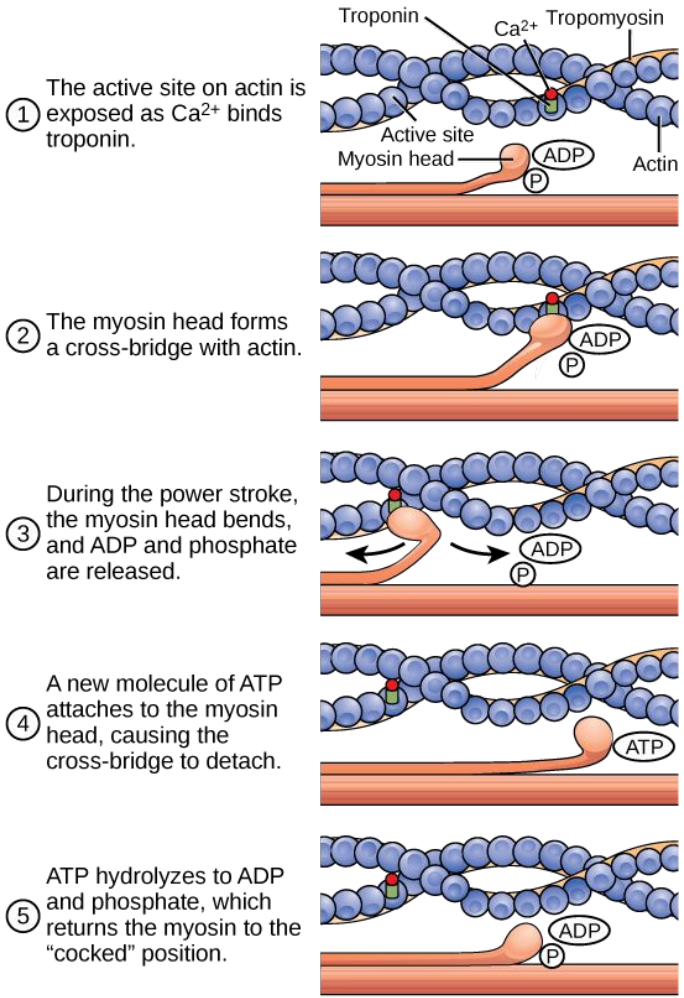
Summary


An action potential arrives at neuromuscular junction
ACh is released, binds to receptors, and opens sodium ion channels, leading to an action potential in sarcolemma
Excitation
Action potential travels along the T-tubules
Calcium
Troponin
ADP
Pi
Thick and thin filament interaction leads to muscle contraction
Muscle shortens and produces tension

Rigor mortis

Our muscles stiffen after death because remember, in order to relax, in order for our myosin heads to detach from the actin

But when we die, we don't create any ATP so our myosin doesn't detach and that's why the body stiffens.



Homework

Write a 1 paragraph summary summarizing how our muscles contract, from start (neurons) to sarcomere shortening.